

CLAIMS

We claim:

1. A formation fluid sampling tool comprising:

at least one sample tank mounted in a tool collar;

the tool collar including a through bore, the tool collar disposed to be operatively coupled with a drill string such that each sample tank may receive a correspondingly preselected formation fluid sample without removing the drill string from a well bore;

at least one of the sample tanks further including an internal fluid separator movably disposed therein, the separator separating a sample chamber from a pressure balancing chamber in the sample tank, the pressure balancing chamber disposed to be in fluid communication with drilling fluid exterior to the pressure balancing chamber; and

a sample inlet port connected to the sample chamber by an inlet passageway.

2. The formation fluid sampling tool of claim 1, wherein the pressure balancing chamber is disposed to be in fluid communication with drilling fluid exterior to tool collar.

3. The formation fluid sampling tool of claim 1, wherein the pressure balancing chamber is disposed to be in fluid communication with drilling fluid interior to the through bore.

4. The formation fluid sampling tool of claim 1, wherein said drilling fluid exterior to the pressure balancing chamber has a pressure about the same as a hydrostatic pressure in the well bore.

5. The formation fluid sampling tool of claim 1, wherein said drilling fluid exterior to the pressure balancing chamber has a pressure exceeding a hydrostatic pressure in the well bore.

6. The formation fluid sampling tool of claim 1, further comprising a plurality of sample tanks.

7. The formation fluid sampling tool of claim 1, wherein at least one of the sample tanks is disposed in the through bore.

8. The formation fluid sampling tool of claim 7, wherein said at least one sample tank disposed in the through bore is disposed substantially co-axially with the tool collar.

9. The formation fluid sampling tool of claim 1, wherein each sampling tank is disposed in the through bore.

10. The formation fluid sampling tool of claim 1, further comprising a pressure control assembly disposed to control flow of drilling fluid between the through bore and the well bore.

11. The formation fluid sampling tool of claim 10, wherein the pressure control assembly comprises at least one drill bit jet.

12. The formation fluid sampling tool of claim 10, wherein the pressure control assembly comprises at least one discharge port to the well bore, each discharge port connected to the through bore by a corresponding outlet passageway, each outlet passageway further including a valve disposed therein for controlling drilling fluid flow
5 between the through bore and the well bore.

13. The formation fluid sampling tool of claim 1, further comprising a valve disposed in the through bore for controlling drilling fluid flow therethrough.

14. The formation fluid sampling tool of claim 1, wherein at least one of the sample tanks is insulated.

15. The formation fluid sampling tool of claim 14, wherein said insulated sample tanks have an r-value of greater than or equal to about 12.

16. The formation fluid sampling tool of claim 1 further comprising a heating module, the heating module in thermal communication with at least one of the sample tanks.

17. The formation fluid sampling tool of claim 16, wherein the heating module comprises an electrical resistance heater.

18. The formation fluid sampling tool of claim 1, wherein the internal fluid separator includes a seal deployed between the sample chamber and pressure balancing chamber.

19. The formation fluid sampling tool of claim 1, further comprising an electronic controller.

20. The formation fluid sampling tool of claim 1, being coupled to a measurement while drilling tool.

21. The formation fluid sampling tool of claim 1, further comprising a pump.

22. A logging while drilling tool comprising:

at least one sample tank mounted in a tool collar;

the tool collar including a through bore, the tool collar disposed to be operatively coupled with a drill string such that each sample tank may receive a correspondingly preselected formation fluid sample without removing the drill string from a well bore;

at least one of the sample tanks further including an internal fluid separator movably disposed therein, the separator separating a sample chamber from a pressure balancing chamber in the sample tank, the pressure balancing chamber disposed to be in fluid communication with drilling fluid exterior to the pressure balancing chamber;

a packer element for sealing the wall of the well bore around the logging while drilling tool; the packer being selectively positionable between sealed and unsealed positions;

a sample inlet port connected to the sample chamber by an inlet passageway.

23. The logging while drilling tool of claim 22, comprising first and second packer elements, the sample inlet port being disposed between the first and second packer elements.

24. The logging while drilling tool of claim 22, further comprising a fluid identification module including at least one sensor disposed to sense a physical property of a formation fluid.

25. The logging while drilling tool of claim 24, wherein at least one of the sensors in the fluid identification module is selected from the group consisting of a

resistivity sensor, a dielectric sensor, a pressure sensor, a temperature sensor, an optical sensor, an acoustic sensor, a nuclear magnetic resonance sensor, a density sensor, a viscosity sensor, and a pH sensor.

26. The logging while drilling tool of claim 24, wherein:

a first fluid passageway connects the fluid identification module to the sample chamber; and

a second fluid passageway connects the fluid identification module to an output port through which fluid may be expelled from the tool.

27. The logging while drilling tool of claim 22, wherein the pressure balancing chamber is disposed to be in fluid communication with drilling fluid exterior to tool collar.

28. The logging while drilling tool of claim 22, wherein the pressure balancing chamber is disposed to be in fluid communication with drilling fluid interior to the through bore.

29. The logging while drilling tool of claim 22, further comprising a plurality of sample tanks.

30. The logging while drilling tool of claim 22, further comprising a pressure control assembly disposed to control flow of drilling fluid between the through bore and the well bore.

31. The logging while drilling tool of claim 22, further comprising a valve disposed in the through bore for controlling a flow of drilling fluid therethrough.

32. The logging while drilling tool of claim 22, wherein at least one of the sample tanks is insulated.

33. The logging while drilling tool of claim 22, further comprising a heating module, the heating module in thermal communication with at least one of the sample tanks.

34. The logging while drilling tool of claim 22, further comprising a pump.

35. An integrated apparatus for retrieving a fluid sample from a well, the apparatus comprising:

a drill string having a drill bit disposed on one end thereof;

a formation evaluation tool disposed on the drill string proximate to the drill bit;

5 and

a formation fluid sampling apparatus also disposed on the drill string proximate to the drill bit, the formation fluid sampling apparatus including:

at least one sample tank mounted in a tool collar;

10 the tool collar including a through bore, the tool collar disposed to be operatively coupled with a drill string such that each sample tank may receive a correspondingly preselected formation fluid sample without removing the drill string from a well bore;

15 at least one of the sample tanks further including an internal fluid separator movably disposed therein, the separator separating a sample chamber from a pressure balancing chamber in the sample tank, the pressure balancing chamber disposed to be in fluid communication with drilling fluid exterior to the pressure balancing chamber; and

a sample inlet port connected to the sample chamber by an inlet passageway.

36. A method for acquiring a formation fluid sample from a formation of interest in a well, the method comprising:

providing a formation fluid sampling tool including at least one sample tank mounted in a tool collar; the tool collar including a through bore, the tool collar disposed to be operatively coupled with a drill string such that each sample tank may receive a correspondingly preselected formation fluid sample without removing the drill string from a well bore; the sample tank including an internal fluid separator movably disposed therein, the separator separating a sample chamber from a pressure balancing chamber in the sample tank, the pressure balancing chamber disposed to be in fluid communication with drilling fluid exterior to the pressure balancing chamber; the sampling tool further including a sample inlet port connected to the sample chamber by an inlet passageway;

coupling the sampling tool with a drill string;

positioning the sampling tool in a well at a location of a formation of interest;

pumping formation fluid into the sample chamber.

37. The method of claim 36, wherein the method further comprises:

coupling a logging while drilling tool to the drill string, the logging while drilling tool in operative communication with the sampling tool; and

logging the well with the logging while drilling tool and thereby determining the location of the formation of interest.

38. The method of claim 36, wherein:

the formation fluid sampling tool further comprises a heating module, the heating module in thermal communication with at least one of the sample tanks; and

the method further comprises utilizing the heating module to heat the formation
5 fluid in at least one of the sample tanks.

39. The method of claim 36, wherein:

the formation fluid sampling tool further comprises a pressure control assembly
disposed to control flow of drilling fluid between the through bore and the well; and
the method further comprises utilizing the pressure control assembly to control the
5 pressure of drilling fluid in the pressure balancing chamber.